Trait Impulsivity and Choice Impulsivity in Young Adults with Probable Binge Eating Disorder

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Research Article

Keywords: Binge eating disorder, impulsivity, discounting task, BIS-11, UPPSP

Posted Date: September 20th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-907763/v1

Abstract

Background

Binge Eating Disorder (BED) as a public health problem has been included in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). Akin to addictive disorders, impulsivity-related neuropsychological constructs might be potentially involved in the onset and development of BED. However, it remains unclear which facets of impulsivity are connected to overeating and binge eating behaviors among non-clinical populations. The present study aimed to detect the relationship between impulsivity and BED both on the personality-trait and behavioral-choice levels in undiagnosed young adults.

Methods

Fifty-eight individuals with probable BED and 60 healthy controls, matched on age, gender, and educational level, were assessed by using a series of self-report measurements, including the Barratt Impulsiveness Scale (BIS-11), UPPSP Impulsive Behaviors Scale (UPPSP), Delay Discounting Test (DDT), and Probability Discounting Test (PDT).

Results

Multivariate analysis of variance models revealed that compared with healthy controls, the BED group showed elevated scores on the BIS-11 Attentional and Motor impulsiveness, and on the UPPSP Negative Urgency, Positive Urgency, and Lack of Perseverance. However, BED subjects had similar discounting rates on the DDT and PDT with healthy controls. Regression models found that Negative Urgency was the only positive predictor of BED.

Conclusions

These findings suggested that typical facets of trait impulsivity, which have been recognized in addictive disorders, were associated with BED in young adults, whereas choice impulsivity was not aberrantly seen in BED. This study might promote a better understanding of the pathogenesis of BED.

Introduction

Binge Eating Disorder (BED) is characterized by overwhelming eating desire with recurrent episodes of binge eating (at least once a week during the last three months) and lack of control over binge-eating behavior[1]. BED has been included as a separate category within the Feeding and Eating Disorders in the latest version of the Diagnostic and Statistical Manual of Mental Disorders (i.e., DSM-5)[2]. The lifetime prevalence for BED in adults is about 3%, with females having a higher risk than males[3]. The prevalence of BED among obese adolescents aged 12–17 years has been reported over 33% in recent literature[4]. Generally, adolescents and young adults have a high risk for BED due to their immature cognitive control abilities[5,6]. Interestingly, although most studies focused on clinical samples of BED, some data showed that in non-clinical populations with a normal Body Mass Index (BMI), over-eating behavior could also be seen with an increase in the risk of developing into BED in these young adults[7,8]. Nevertheless, it remains unclear which neuropsychological constructs might be potentially linked to BED among general adolescents and young adults.

Impulsivity is a hallmark feature in various mental disorders including addictive behaviors, as well as in so-called “food addiction”, which has been largely controversial[8]. Many studies suggested that impulsivity might be a vulnerability trait for both behavioral and substance-related addictions[9,10,11]. Importantly, individuals with BED and substance abusers shared similar intense cravings, disinhibition over the intake of foods or drugs, and altered reward sensitivity[12,13]. Therefore, impulsivity might also play a part in the onset of BED. However, the relationship between impulsivity and BED remains to be further understood.

Impulsivity refers to a tendency to act without careful thinking or to react prematurely[14,15,16,17]. Although impulsivity is a multifaceted construct, at least two different connotations of impulsivity may be separately detected with different measurements[18], that is, personality-level trait impulsivity, measured by some self-report scales such as the Barratt Impulsiveness Scale (BIS-11)[19], and behavioral-level choice impulsivity, assessed by some reward discounting tasks such as the Delay-discounting Test (DDT)[20].

Trait impulsivity is a stable and inheritable feature with self-reported attributions of self-regulatory ability[21]. Many previous studies have linked trait impulsivity to binge eating behaviors in clinical patients with BED [22,23,24]. Nevertheless, these samples always had high comorbidity with

attention-deficit/hyperactivity disorder (ADHD)[25], anxiety disorders[26], and substance use disorders[27], which might lead to confounding results when detecting the relationship between impulsivity and BED. Moreover, limited data on the associations of trait impulsivity and BED have been incongruous among general populations. Some data suggested that heightened impulsivity was found in young adults with BED compared to healthy controls[28,29,30,31], while other studies showed no group differences[32,33]. Findings were also inconsistent when specific facets of impulsive traits were taken into account[8,34,35]. One prior study found that Attentional, Motor, and Non-planning Impulsiveness were significantly related to binge eating in normal-weighted females[24], while another study showed that only Attentional and Motor Impulsiveness were elevated in obese patients with overeating[33].

Comparatively, choice impulsivity is considered an irrational decision-making process influenced by motivations and affects[36,37,38]. Meta-analyses have demonstrated that increased choice impulsivity might be particularly relevant to BED[39,40,41]. Clinical patients with BED, including both normal-weighted and over-weighted, displayed steeper delay discounting than healthy controls[35,42,43]. Nonetheless, it is unclear whether the aberrant delay discounting was truly connected to BED itself or rooted in the comorbid psychiatric disorders in these clinical patients[44]. Despite little evidence, several studies with non-clinical samples revealed that adults with BED exhibited steeper delay discounting compared to controls[45,46]. However, negative results showed that BED individuals and healthy controls had no differences on delay discounting tasks[47,48]. Regarding probability discounting, limited studies suggested that obese women with BED tended to discount probabilistic rewards less steeply than healthy controls[45,49,50], though our prior data displayed similar probability discounting in young adults with and without BED[51]. Thus,more studies are needed to elucidate the relationship between binge-eating behaviors and choice impulsivity among general populations[52].

The current study aimed to further detect the associations between impulsivity and binge eating among non-treatment-seeking samples. The Barratt Impulsiveness Scale-11 (BIS-11) and UPPSP Impulsive Behaviors Scale (UPPSP) were employed to measure trait impulsivity, and the Delay Discounting test (DDT) and Probability Discounting test (PDT) were used to assess choice impulsivity, comparing probable BED subjects with healthy controls (HCs). It was generally hypothesized that heightened trait impulsivity and choice impulsivity would be linked to BED, as possible risk factors or vulnerability markers for binge eating behaviors.

Methods

Participants and procedure

Participants were recruited through posters from a local university in Guiyang, China. Power analyses[53] were conducted to determine a target sample size (Cohen' s $d = 0.4$, $\alpha = 0.05$, $1-\beta = 0.8$, F tests, G*Power), with a minimum sample size of 52 (at least $n = 26$ in each group). Subjects were invited to provide demographic information and complete a series of self-report questionnaires in the laboratory. Inclusion criteria included: 1) ≧ 18 years of age, and 2) willingness to participate in this study. Exclusion criteria included: 1) past or current severe psychiatric disorders (e.g., schizophrenia, bipolar disorder), 2) a history of illegal psychoactive substance use (e.g., cocaine, heroin, amphetamine), and 3) brain trauma or neurological diseases, which were evaluated by self-reports. Probable BED status was estimated by using the Chinese version of the Binge Eating Scale (BES) [54]. BES is a 16-item self-report questionnaire designed to assess behavioral, emotional, and cognitive symptoms of binge eating. Items were rated on a 5-point Likert scale from 0 (not at all) to 4 (very much), with a total score ranging from 0 to 46. Higher total scores indicate more severe binge eating problems, with a score of ≧ 18 indicating probable binge eating disorder (BED)[55].

Finally, the BED group consisted of 58 subjects (mean age = 19.34 ± 1.15 years; 10 males, 17.24%; mean BES score = 21.78 ± 4.02). The healthy controls (HCs) included 60 subjects, matched on age, gender, and educational level with the BED group (mean age = 19.10 ± 0.78 years; 10 males, 16.67%; mean BES score = 5.43 ± 2.23). All subjects gave informed consent and were compensated with a gift equal to RMB ¥50. The current study was reviewed and approved by the Human Research Ethics Committee at the Guizhou Medical University. The proposed study design, recruitment process, and our plans to compensate the participants were in accordance with the Declaration of Helsinki.

Measures

Body Mass Index (BMI). Standard procedures were used to measure weight and height, and BMI was calculated as weight divided by the square of height (i.e., kg/ m^2).

Trait Impulsivity. Participants completed the Chinese version of the Barratt Impulsiveness Scale (BIS-11)[56], a 30-item self-report inventory that measures impulsive personality in terms of three factors: Motor Impulsiveness, Attentional Impulsiveness, and Non-planning Impulsiveness. Items were rated on a 4-point Likert scale. A higher score of each dimension indicates a higher level of trait impulsivity. The *Cronbach's s α* was 0.796 in this study. Participants also completed the UPPSP Impulsive Behaviors Scale (UPPSP)[57], which is a 59-item self-report questionnaire used to assess five dimensions of impulsive personality: Sensation Seeking, Lack of Premeditation, Lack of Perseverance, Negative Urgency, and Positive Urgency. Items were rated on a 4-point Likert scale. The *Cronbach's α* was 0.878 in this study.

Choice Impulsivity. The Delay Discounting Test (DDT) and Probability Discounting Test (PDT) were used to evaluate choice impulsivity. Both tasks were designed to evaluate discounting degrees of hypothetical monetary rewards. The DDT[58] is a fixed serial of 27-item choice questionnaire between a smaller immediate monetary reward and a larger delayed monetary reward. For the DDT, k parameter indicates the degree of delay discounting, calculated by the equation: $V = A/(1 + kD)$. In this equation, V refers to the individual subjective value of the delayed reward, A is the nominal amount of the delayed reward, and D is the length of the delay. A higher k indicates a higher degree of delay discounting. The PDT[51] is a three-part monetary choice questionnaire, with 10 items in each part. Participants were told to choose between a smaller amount of monetary reward obtained for sure and a larger amount of monetary reward obtained probabilistically (e.g., "$20 for sure" *VS* "10% chance of obtaining $80"). *The h* parameter is calculated by the hyperbolic equation: $V = A/(1 + h\theta)$. In this equation, V refers to the present subjective value of the probabilistic reward A. A lower h value implies that the probabilistic rewards are less steeply discounted, suggesting a reduction in risk aversion.

Statistical Analyses

Data analysis was performed with the Statistical Package for the Social Sciences for Windows, Version 22.0. (SPSS Inc., Chicago, IL, USA). Chi-square tests were used to test group differences on categorical variables (i.e., ethnicity, gender, home locality, smoking, and drinking status). T-tests were used to analyze group differences on Body Mass Index (BMI) and age. Multivariate analysis of variance (mANOVA) models were used to compare task scores between the two groups. Partial correlations were tested between the BIS, UPPSP, DDT, PDT, and BES scores, controlling for age, BMI, gender, ethnicity, home locality, smoking, and drinking status. In addition, a multivariate linear regression analysis was conducted to test the effects of the impulsivity scores on BES scores, and logistic regression analyses were used to test the predictive effects of different dimensions of impulsivity on binge eating behavior. According to the standardized variance inflation factor *(VIF)*, multi-collinearity was not a problem for any variable in these regression models ($VIF < 10$). Significance was defined as $p < 0.05$, two-tailed.

Results

Demographic characteristics

Table 1 illustrated the demographics and task scores of the two groups. The BED group had a higher BMI than the HCs ($t = 3.65$, $p = 0.001$). No between-group differences were found for age ($p = 0.18$), ethnicity ($p = 0.60$), gender ($p = 0.93$), or home locality ($p = 0.75$).

Table 1
Demographic characteristics and impulsivity measures of the sample (N = 118)

Variables	BED group (n = 58)	HCs (n = 60)	χ^2/t	P
Age, years(M ± SD)	19.34 ± 1.15	19.10 ± 0.78	1.35	0.180
BMI (kg/m^2)(M ± SD)	22.07 ± 4.43	19.87 ± 1.23	3.65	0.001
Ethnicity, Hans n (%)	31 (53.4)	35 (58.3)	0.29	0.600
Gender, Male n (%)	10 (18.5)	10 (16.7)	0.01	0.930
Home locality, Urban n (%)	44 (75.9)	44 (73.3)	0.10	0.750
Smoking status, yes n (%)	2 (0.04)	0(0)	-	-
Drinking status, yes n (%)	2 (0.04)	0(0)	-	-
BIS-11 scores(M ± SD)				
Attentional Impulsiveness	0.40 ± 0.91	-0.38 ± 0.92	4.64	0.001
Motor Impulsiveness	0.25 ± 1.04	-0.24 ± 0.90	2.81	0.010
Non-planning Impulsiveness	0.15 ± 1.01	-0.14 ± 0.96	1.63	0.110
UPPSP scores(M ± SD)				
Negative Urgency	0.53 ± 0.78	-0.52 ± 0.91	6.76	0.001
Lack of Premeditation	0.05 ± 1.07	-0.05 ± 0.92	0.58	0.560
Lack of Perseverance	0.25 ± 1.03	-0.24 ± 0.91	2.76	0.010
Sensation Seeking	0.05 ± 1.04	-0.05 ± 0.95	0.62	0.540
Positive Urgency	0.39 ± 0.88	-0.37 ± 0.96	4.49	0.001
DDT scores(M ± SD)				
k value	0.03 ± 0.06/	0.01 ± 0.01/	2.36/	0.020/
/(log-transformed)	-2.07 ± 0.82	-2.2 ± 0.61	1.04	0.300
PDT scores(M ± SD)				
Part A ($20 vs $80) *h* value	2.93 ± 3.08/	3.83 ± 3.68/	-1.43/	0.160 /
/(log-transformed)	0.22 ± 0.48	0.39 ± 0.42	-2.01	0.047
Part B ($40 vs $10) *h* value	2.48 ± 3.33/	2.07 ± 2.32/	0.77/	0.440 /
/(log-transformed)	0.12 ± 0.46	0.14 ± 0.37	-0.22	0.830
Part C ($40 vs $60) *h* value	2.03 ± 3.25/	1.84 ± 3.18/	0.31/	0.760/
/(log-transformed)	0.01 ± 0.46	-0.02 ± 0.43	0.43	0.670

Note. BED = Binge Eating Disorder; HC = Healthy controls; BIS = Barratt Impulsiveness Scale, UPPSP = UPPSP Impulsive Behaviors Scale, DDT = Delay-discounting Test, PDT = Probability Discounting Test, *k* represents the discounting rate and *h* represents the probability discounting rate.

Trait Impulsivity

On the BIS-11, the mANOVA models revealed significant between-group differences on Attention Impulsiveness ($F_{(1,115)}$ = 18.769, p = 0.001, η^2_p=0.140) and Motor Impulsiveness ($F_{(1,115)}$ = 10.394, p = 0.002, η^2_p=0.083), but not on Non-planning Impulsiveness ($F_{(1,115)}$ = 3.793, p = 0.054). Post-hoc comparisons found that the BED group had higher scores on Attentional Impulsiveness (M_d=2.643, p = 0.001, *Cohen's d* = 0.855) and Motor Impulsiveness (M_d=2.112, p = 0.002, *Cohen's d* = 0.516) than the HCs.

On the UPPSP, the mANOVA models showed significant between-group differences on Negative Urgency ($F_{(1,115)}$ = 52.387, p = 0.001, η^2_p=0.313), Lack of Perseverance ($F_{(1,115)}$ = 5.310, p = 0.023, η^2_p=0.044), and Positive Urgency ($F_{(1,115)}$ = 20.553, p = 0.001, η^2_p=0.152), but not on Lack of Premeditation ($F_{(1,115)}$ = 0.548, p = 0.461) and Sensation Seeking ($F_{(1,115)}$ = 0.890, p = 0.347). Post-hoc comparisons displayed that the BED group

had higher scores on Negative Urgency (M_d=6.288, p = 0.001, *Cohen's d* = 1.246), Lack of Perseverance (M_d=1.515, p = 0.023, *Cohen' s d* = 0.508), and Positive Urgency (M_d=5.226, p = 0.001, *Cohen' s d* = 0.828) than HCs.

Choice Impulsivity

On the DDT, the mANOVA model displayed no significant between-group differences on the log-transformed *k*-value ($F_{(1,115)}$ = 1.251, p = 0.266). On the PDT, the mANOVA model found significant between-group differences on the log-transformed *h* value (Part A) ($F_{(1,115)}$ = 4.076, P = 0.046, η^2_p=0.034), but not on the Part B ($F_{(1,115)}$ = 0.592, p = 0.443) or the Part C ($F_{(1,115)}$ = 0.017, p = 0.896). Post-hoc comparisons showed that the BED group had lower *h* scores than the HCs on the Part A (M_d =0.181, p = 0.046, *Cohen' s d* = 0.370).

Partial Correlation and Linear Regression Outcomes

As seen in Table 2, significant positive correlations were detected between the BES scores and BIS-11 Attentional Impulsiveness, Motor Impulsiveness, Non-planning Impulsiveness, UPPSP Negative Urgency, Lack of Perseverance, and Positive Urgency scores (r_p=0.24–0.57, ps< 0.05). Nevertheless, no significant correlations were detected between the BES scores and UPPSP Lack of Premeditation, Sensation Seeking, DDT *k* value (log-transformed), and PDT *h* values (log-transformed) of three parts.

Table 2
Partial Correlations analyses of impulsivity measures and BES scores(N= 118).

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1.BES score	-											
2.BIS Attentional Impulsiveness	0.39***	-										
3.BIS Motor Impulsiveness	0.25**	0.51***	-									
4.BIS Non-planning Impulsiveness	0.24*	0.55***	0.59***	-								
5.UPPSP Negative Urgency	0.57***	0.53***	0.36***	0.28**	-							
6.UPPSP Lack of Premeditation	0.15	0.31***	0.45***	0.67***	0.10	-						
7.UPPSP Lack of Perseverance	0.30**	0.53***	0.41***	0.65***	0.32**	0.53***	-					
8.UPPSP Sensation Seeking	0.08	0.03	-0.11	-0.22*	0.14	-0.21*	-0.34***	-				
9.UPPSP Positive Urgency	0.37***	0.40***	0.32**	0.19*	0.74***	0.03	0.27**	0.19*	-			
10.DDT *k* (log-transformed)	0.09	0.13	-0.02	-0.01	0.18	-0.06	0.01	0.05	0.24**	-		
11.PDT Part A *h* (log-transformed)	-0.16	-0.05	0.11	0.10	-0.07	-0.01	0.04	-0.22*	-0.09	-0.20*	-	
12.PDT Part B *h* (log-transformed)	-0.08	-0.07	0.12	0.04	-0.01	0.01	0.10	-0.18	0.01	-0.17	0.66***	-
13.PDT Part C *h* (log-transformed)	0.17	0.17	0.19	0.19*	0.10	0.11	0.18	-0.05	0.12	-0.12	0.35***	0.61***

Note. BES = Binge Eating Scale; BIS = Barratt Impulsiveness Scale-11, UPPSP = UPPSP Impulsive Behaviors Scale. DDT = Delay-discounting Test; PDT = Probability Discounting Test, *k* represents the delay discounting rate, and h represents the probability discounting rate. Control variables: BMI, Age, Ethnicity, Gender, Home locality. * p< 0.05, ** p< 0.01, *** p< 0.001.

The multivariate linear regression analyses were used to test the effect of BIS, UPPSP, DDT, and PDT scores on the BES scores, with a 2-step design. BMI was entered in step 1 as the control variable, and the impulsivity scores were entered in step 2 as the predictor variables. Table 3 displayed that only UPPSP Negative Urgency positively predicted the BES scores, after controlling for the effect of BMI ($F_{(13, 104)} = 4.53$, $p < 0.001$; $\Delta R^2 = 0.33$, $p < 0.001$).

Table 3
Multivariable linear regression analyses of impulsivity measures on BES scores ($N = 118$).

Models	Standardized Coefficient (β)	t	F	R	R^2	ΔR^2
Step 1			2.50*	0.35	0.12	0.12*
BMI	0.33	3.53**				
Step 2			4.53***	0.67	0.45	0.33***
BMI	0.32	3.74***				
BIS Attentional Impulsiveness	0.04	0.36				
BIS Motor Impulsiveness	0.02	0.15				
BIS Non planning Impulsiveness	0.01	0.11				
UPPSP Negative Urgency	0.60	4.69***				
UPPSP Lack of Premeditation	0.00	0.00				
UPPSP Lack of Perseverance	0.13	1.07				
UPPSP Sensation Seeking	0.05	0.51				
UPPSP Positive Urgency	-0.15	-1.22				
DDT *k* (log-transformed)	-0.02	-0.27				
PDT Part A *h* (log-transformed)	-0.13	-1.27				
PDT Part B *h* (log-transformed)	0.03	0.23				
PDT Part C *h* (log-transformed)	-0.03	-0.31				

Note. BES = Binge Eating Scale; BIS = Barratt Impulsiveness Scale-11, UPPSP = UPPSP Impulsive Behaviors Scale. DDT = Delay-Discounting Test; PDT = Probability Discounting Test, *k* represents the delay discounting rate, and *h* represents the probability discounting rate. Control variable: BMI. Dependent variable: BES scores. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Logistic Regression Outcomes

The binary logistic regression models were conducted to examine the effects of the impulsivity scores on binge-eating behavior. A 2-step design was used: BMI was entered in step 1 as the control variable, and the three dimensions of BIS-11 (Attentional Impulsiveness, Motor Impulsiveness, and Non-planning Impulsiveness), five dimensions of UPPSP (Negative Urgency, Lack of Premeditation, Lack of Perseverance, Sensation Seeking, and Positive Urgency), DDT *k* value (log-transformed), and PDT *h* values (log-transformed) were entered in step 2. Table 4 revealed that only Negative Urgency positively predicted binge eating behavior ($OR = 1.50$, $p < 0.001$, *Nagelkerke* $R^2 = 0.608$ for the model).

Table 4
Logistic regression analyses of impulsivity scores on BED controlling for BMI (*N* = 118).

Models	BED		
	B	Wald χ^2	OR (95% CI)
Step 1			
BMI	0.42	11.44***	1.52 (1.19–1.95)
Step 2			
BIS Attentional Impulsiveness	0.08	0.43	1.09 (0.85–1.38)
BIS Motor Impulsiveness	0.11	1.08	1.12 (0.90–1.39)
BIS Non planning Impulsiveness	-0.01	0.01	0.99 (0.80–1.25)
UPPSP Negative Urgency	0.41	14.96***	1.50 (1.22–1.84)
UPPSP Lack of Premeditation	-0.07	0.52	0.93 (0.77–1.13)
UPPSP Lack of Perseverance	0.05	0.20	1.06 (0.83–1.34)
UPPSP Sensation Seeking	-0.03	0.26	0.97 (0.88–1.08)
UPPSP Positive Urgency	-0.06	0.86	0.94 (0.82–1.07)
DDT *k* (log-transformed)	-0.16	0.15	0.86 (0.39–1.88)
PDT Part A *h* (log-transformed)	-1.26	2.76	0.29 (0.07–1.26)
PDT Part B *h* (log-transformed)	0.12	0.01	1.13 (0.15–8.43)
PDT Part C *h* (log-transformed)	-0.56	0.54	0.57 (0.13–2.58)

Note. BED = Binge Eating Disorder; BIS = Barratt Impulsiveness Scale-11, UPPSP = UPPSP Impulsive Behaviors Scale. DDT = Delay-discounting Test; PDT = Probability Discounting Test, *k* represents the delay discounting rate, and *h* represents the probability discounting rate. *CI* = confidence interval, *OR* = odds ratio; ***$p < 0.001$

Discussion

To the best of our knowledge, the present study was the first to examine the associations between trait impulsivity, choice impulsivity, and binge-eating behavior in non-clinical samples. The results supported our hypotheses that individuals with probable binge eating disorder (BED) might have elevated impulsive personality traits than the healthy controls. Specifically, the BED subjects showed higher levels of trait impulsivity on the BIS-11 (i.e., Attentional Impulsiveness, Motor Impulsiveness) and UPPSP (i.e., Negative Urgency, Lack of Perseverance, Positive Urgency). However, the BED group had a normal level of choice impulsivity both on the DDT and the PDT (except on the PDT Part A), compared with the healthy controls. Significant positive correlations were found between BES scores and most impulsivity scores, including BIS-11 Attentional Impulsiveness, Motor Impulsiveness, Non-planning Impulsiveness, UPPSP Negative Urgency, Lack of Perseverance, and Positive Urgency. More importantly, regression models showed that only Negative Urgency positively predicted binge eating behavior as a potential risk factor. These findings suggested that different impulsivity facets were separately associated with BED, and certain trait impulsivity (Negative Urgency) might be considered a hallmark for BED in non-clinical young adults.

Increased impulsivity has been proposed as a phenotype for addictive disorders as well as within the clinical obesity spectrum, and it might also increase the onset of BED[59]. However, few studies have focused on the relationship between impulsivity and binge eating in non-treatment-seeking individuals with normal weight. The current study investigated the associations of trait impulsivity, choice impulsivity, and binge-eating behavior in common populations (i.e., young adult college students). The data showed that individuals with BED had elevated scores on measurements of trait impulsivity (i.e., Attentional Impulsiveness, Motor Impulsiveness, Negative Urgency, Lack of Perseverance, and Positive Urgency), consistent with previous reports on BED[34,60,61,62,63] and addictive disorders[64,65,66].

Furthermore, positive correlations were found between the BES scores and these impulsivity scores (Table 2). However, only Negative Urgency displayed the main effect as a significant indicator of binge-eating behavior in the regression models (Tables 3 and 4). This finding suggested that elevated Negative Urgency might represent a preclinical susceptibility marker for binge eating disorder, although longitudinal studies are needed to clarify whether Negative Urgency precedes the onset of binge eating behavior or as a consequence of BED. Nevertheless, our first direct evidence in non-treatment-seeking populations showed that specific trait of impulsivity (i.e., Negative Urgency) was overtly enhanced in binge-eating behavior[67,68,69]. Negative urgency reflects a tendency to act impulsively under the condition of extreme negative emotions[70]. Individuals with elevated Negative Urgency seemed more likely to be involved into binge eating in order to deal with negative emotions, and as a

result, their binge-eating behaviors would be further reinforced or deteriorated[71]. Our results increased new knowledge to the current literature that Negative Urgency could play a key role for BED even in non-clinical samples, as a possible susceptible hallmark of binge-eating behaviors, which should promote a better understanding of the pathogenesis of BED.

On the other side, the BED group did not show an aberrant pattern of choice impulsivity. The data revealed that individuals with probable BED performed similarly with the healthy controls on the Delay Discounting Test (DDT) and the Probability Discounting Test (PDT), though the BED group displayed a lower probability-discounting degree on the PDT Part A (i.e., $20 *VS* $80) with a low to medium effect size (*Cohen' s d* = 0.370). Moreover, the DDT *k* value and PDT *h* values were not significantly associated with or predictive of binge eating (Tables 2–4). Recent studies found that obese females with BED had higher discounting degrees of delayed reward[72], and addictive drug abusers displayed a lower risk aversion compared to matched controls[73,74]. Among clinical samples of BED as well as those of obesity without BED, reduced reward processing in the striatal and amygdala regions indicated motivational hypofunction to non-food rewards[75,76]. Nevertheless, a longitudinal study showed that the ventromedial prefrontal cortex (vmPFC) activation did not display a significant effect on the severity of binge-eating behaviors in adolescent girls[77]. Therefore, further studies should be conducted to investigate the processes of delay gratification and risk aversion in both clinical and non-clinical samples of BED in future.

Several limitations should be noted in the current study. Firstly, this study was a cross-sectional design in nature, and thus could not draw a causal conclusion between impulsivity and BED. Moreover, the samples mainly consisted of young college students and the results could not be generalized to clinical samples with serious binge-eating problems. Future research should investigate the relationship of specific trait impulsivity (e.g., Negative Urgency) with binge-eating behaviors in more severe clinical patients. Thirdly, given that our study mainly focused on some aspects of impulsivity (i.e., trait impulsivity and choice impulsivity) measured by self-report scales, these findings should be interpreted more carefully because of the possible subjective bias, and other facets of impulsivity should be further investigated using more objective tasks.

In despite of these limitations, the present study firstly looked into the associations between various aspects of impulsivity and binge-eating behavior in non-clinical samples of BED, using a case-control design. Our results indicated that Attentional Impulsiveness, Motor Impulsiveness, Negative Urgency, Lack of Perseverance, and Positive Urgency were elevated in BED, and especially, Negative Urgency was the only positive predictor of BED. These findings suggested that typical facets of trait impulsivity, which have been recognized in addictive disorders, were associated with BED in young adults, whereas choice impulsivity was not aberrantly seen in BED.

Declarations

Ethics approval and consent to participate

The procedures reported in this study were reviewed and approved by the Human Research Ethics Committee at the Guizhou Medical University, and the proposed recruitment process, study design and plans to compensate participants were carried out in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The data and materials are available and could be requested and addressed to the corresponding author (email: yanwansen@163.com).

Competing interests

There are no competing interests declared by all the authors.

Funding

This study was supported by the National Natural Science Foundation of China (NO.s: 32060195, 31560284) to Dr. W.S. Yan.

Authors' contributions

W-S Y designed the study, wrote the protocols, directed the study, and wrote first draft of the manuscript. D-H Z performed the main data analysis and assisted to write the first draft of the manuscript. M-M L contributed to the assessments and data collection. All of the authors contributed to this article and have approved the final manuscript.

Acknowledgments

The authors are thankful for all the participants in this study.

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